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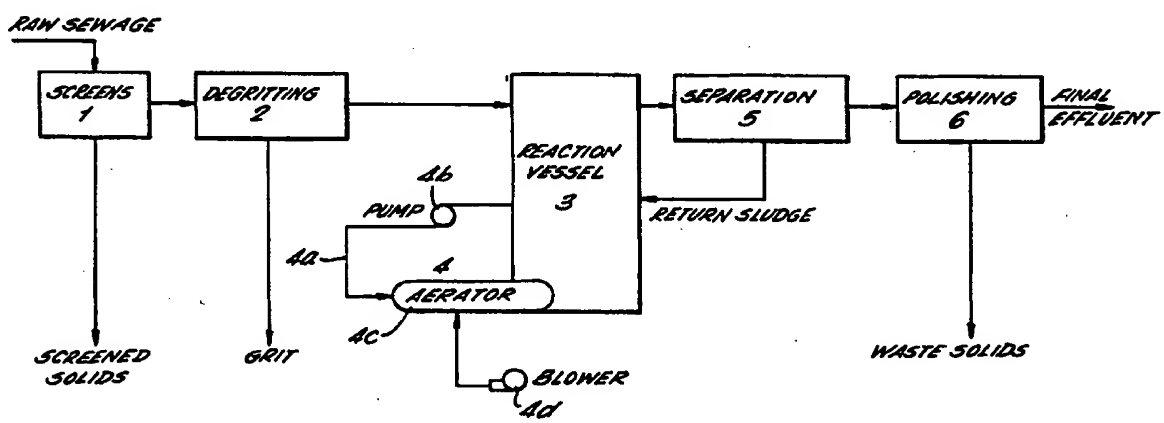



## (57) Abstract

Organic material in waste water is treated by aerobic digestion by bacteria in a reaction vessel. A proportion of the bacteria in the reaction vessel are deactivated to modify the concentration of active bacteria. This deactivation is accomplished by providing a region of high mechanical shear stress in the liquid so that flocs of bacteria are broken up. Resulting loose bacterial cells and small floc particles encourage an increase in the population of higher life forms, protozoa and rotifers, which predate on these lone cells and small particles. By controlling the level of predation by higher life forms, the effective death rate of bacteria is increased so that the overall biomass in the reaction zone can be maintained constant even though sufficient organic material is supplied in the waste water for the bacterial population to respire as in a growth phase. The resulting high respiration rate minimises the overall production of sludge without excessive residence times in the reaction zone.

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# METHODS AND APPARATUS FOR USING MICRO-ORGANISMS TO TREAT ORGANIC MATERIAL FOUND IN WASTE WATER

The present invention relates to methods of using micro-organisms to treat organic material found in waste water and to apparatus for putting the methods into effect. The present invention is directed towards the treatment of waste water to yield an environmentally acceptable effluent. It is envisaged that the present invention may be used to treat all types of biodegradable waste water or sewage, including municipal, industrial and agricultural waste water.

Waste water commonly contains both organic and inorganic solids of various forms. In addition, organic material is commonly present in the waste water in solution and as colloidal and/or particulate matter. A standard measure of the organic material present in the waste water is its Biological Oxygen Demand (BOD). Waste water having a high BOD tends to encourage the proliferation of micro-organisms which feed on the organic material. When such waste water is discharged into natural waters such as rivers. The micro-organisms will consume any oxygen dissolved in the water, resulting in an environment which will not support higher forms of life such as plant life or fish. Discharge of waste water having a high BOD is therefore environmentally unacceptable. In addition, the presence of pathogenic micro-organisms and toxic compounds in particular waste waters constitutes a health hazard. Regulations are now being effected in many countries in which the discharge of

effluent not environmentally acceptable will incur substantial financial penalties.

A typical treatment scheme for treating waste water containing organic material can involve a number of treatment stages although not all of these stages may be necessary for every effluent. A pre-treatment is required if the effluent contains gross inorganic solids or very high concentrations of fats. The pre-treatment stage may also be useful for balancing concentrations if these vary excessively. A primary or pre-biological treatment stage is generally necessary if the waste water contains organic solids which may be readily separable. This pre-biological treatment stage will include a separation stage which produces an organic sludge and an effluent. The effluent from the pre-biological treatment stage is passed to a biological treatment stage which is used to convert organic material still dissolved or held in suspension in the effluent into an organic sludge which can be separated from the effluent, or into mineralised products. The sludge produced by the pre-biological treatment and biological treatment stages may be treated to reduce its volume and to convert it to a more environmentally acceptable form. The effluent from the biological treatment stage may be further treated to reduce the level of fine suspended solids, to reduce the concentration of mineralised products from the pre-biological and biological treatments, or to reduce the concentration of toxic or persistent compounds in the effluent before final discharge into the environment.

Numerous aerobic processes have been developed over the years for the biological treatment of waste water to yield an environmentally acceptable effluent. One widely used aerobic process for such treatment is referred to as the activated sludge process, so called as it involves the production of an activated mass of

micro-organisms capable of stabilising a waste aerobically. Organic material in the waste water is converted into a solid form which can be separated from purified water. A portion of the insoluble sludge that is formed is recycled to the aerobic zone to maintain a specific solids concentration and biological activity.

In the activated sludge process the bacteria are the most important micro-organisms because they are responsible for the decomposition of the organic material in the waste water. The bacteria form flocs which is a prerequisite for the effective separation of the biological solids in the settling unit. The flocs also trap solids in the waste water for subsequent degradation. The metabolic activites of other micro-organisms are also important in the activated sludge system. Protozoa and rotifers act as effluent polishers since protozoa consume dispersed bacteria that have not flocculated, and rotifers consume small biological floc particles that have not settled. The protozoa and rotifers are typically less than 5% of the dry weight in activated sludge solids.

Many versions of the activated sludge process are in use, but fundamentally they are all similar. In these systems there is a significant net positive production of sludge containing suspended solids in the process. Excess sludge must be discarded on a periodic basis from the process. The excess sludge may, in theory, simply be discharged to land or water, but more usually the cost of transport and environment legislation make treatment of the sludge necessary before disposal. In particular, the presence of micro-organisms in the sludge may, as in the waste water, constitute a health hazard and result in an environmentally unacceptable discharge. A major cost of biological effluent treatment is that associated with the processing of the solid - the thickening, stabilisation

and dewatering required to dispose of the sludge. Sludge costs are typically 50% of total treatment costs. Thickening is generally employed to further concentrate the solids in the sludge prior to stabilisation or further digestion. Thickening may be accomplished by gravity thickening, pressing or dissolved air flotation. Various processes have been proposed to stabilise the sludge or to reduce the production of sludge.

Various processes have been proposed to stabilise the sludge or to reduce the production of sludge. One proposed technique for treating such sludge involved extended aeration which increased the degree of auto-oxidation, i.e. the sludge became self consuming to some degree by a process known as endogenous respiration, and there was a net reduction of such sludge. Unfortunately, the rate of oxidation was generally too low to have a significant effect on net sludge production. Furthermore, the requirement for extending the time for which the sludge was exposed to the micro-organisms created further problems because of large plant size and high operating costs.

US-A-4915840 (Rozich - Assigned to Bio Process Engineering Inc.) discloses a process involving hydrolysis of the heavy sludge fraction and the use of an auto thermal aerobic digester zone. In the basic process, sewage is charged to a primary clarifier where grit and inorganic and heavy organic materials are separated from the waste water by gravity to leave organic material dissolved or suspended in the water. The effluent from the primary clarifier is then charged to an initial aerobic zone where the organic material remaining in the effluent is contacted with an oxygen containing gas and biologically active organisms. This results in a mixed liquor of liquid and organic solids which is then separated into a heavy sludge fraction and a disposable

effluent (which can be discharged to the external environment). The heavy sludge fraction comprising organic solids and some liquid is hydrolysed by contact with acid or base and the resulting hydrolysed sludge is combined with sediment from the primary clarifier and charged to an auto thermal aerobic digester zone. The extent of hydrolysis is controlled such that the rate of biological digestion in the auto thermal aerobic digester zone results in the production of an effluent containing a preselected concentration of organic matter. By proper control, a preselected net generation of sludge is produced by the aerobic sludge generating process thereby resulting in an overall preselected sludge reduction. In one example disclosed, the mean hydraulic time for the aerobic time was eight hours and the mean hydraulic time for the auto thermal aerobic digester was 18 days.

It is an object of the present invention to provide improved methods and apparatus for treating organic material found in waste water with minimum net sludge production. In considering the prior art processes, the inventors have appreciated that a significant feature of the treatment of sludge is the control of the concentration of micro-organisms present in the aerobic zone. Micro-organisms exposed to organic material in the presence of oxygen will consume the organic material to grow and reproduce. The conversion of organic material to micro-organism biomass is not 100% efficient as some of the organic material is broken down into carbon dioxide and water during the process of respiration required to generate energy for growth and reproduction. In addition, there are maintenance energy requirements by the microbial cell which is supplied by both substrate breakdown and biomass degradation.

The overall demand from both maintenance energy supplying routes is substrate dependent, and energy from biomass degradation is in itself growth-rate dependent. In conventional activated sludge systems as micro-organisms reproduce by dividing, there is a net exponential increase in micro-organisms if sufficient organic material and oxygen is made available, resulting in the above mentioned net sludge production. If the system is substrate limited, cell growth is lower and therefore less sludge is produced but with the disadvantage of much slower substrate removal rates.

The use of the extended aeration process reduces the net production of sludge because it limits the organic material available to the micro-organisms. Thus, the rate of production of new micro-organisms is decreased and the natural processes of cell death and endogenous respiration (respiration using the stored organic material in the micro-organisms) result in a net negative growth rate. In auto thermal aerobic digestion, the digester is operated at elevated temperatures such that the rate of biological digestion is increased at these higher temperatures. However, although the rate of biological digestion is increased in auto thermal aerobic digestion, it appears that the principle of extended aeration is still used as indicated by the hydraulic residence time, in the example of US-A-4915840, of 18 days.

In contrast to the above approaches, the inventors have appreciated that the production of sludge may be controlled or even eliminated by deactivating a proportion of the bacteria present in the system. In this way the total number of bacteria in a reaction zone can be maintained substantially constant whilst maintaining a high rate of aerobic digestion and respiration.

In one aspect the invention provides a method of using micro-organisms to treat organic material found in waster water, the method including the steps of:

a) supplying waster water to a reaction zone for aerobic digestion of organic material in the waster water by bacteria;

b) removing a portion of the contents of the reaction zone to produce a liquid fraction and a separated sludge fraction;

c) returning the whole of the separate sludge fraction to the reaction zone; and

d) deactivating a proportion of the bacteria in the reaction zone to modify the concentration of active bacteria in the reaction zone.

In this aspect of the present invention, the inventors have appreciated that, if the quantity of bacteria in the reaction zone is controlled, then sludge generated by the bacteria in the reaction zone may be maintained in the reaction zone instead of having to be separated and treated in a separate process. Thus, when a liquid fraction is removed from the aerobic zone as effluent, any sludge removed with the liquid fraction may be separated and returned to the reaction zone and used in the aerobic digestion. Separate treatment of sludge is thereby avoided and the product of the treatment is primarily carbon dioxide and water which can be easily disposed.

Advantageously, the organic material supplied to the reaction zone in the wastewater is sufficient for the bacteria population in the reaction zone to be respiring as in a growth phase, preferentially as in an exponential growth phase. In view of the control of the concentration of bacteria in the reaction zone, it is not necessary for sludge reduction,to operate the treatment system in a

state where the growth of bacteria/biomass does not exceed the normal reduction of biomass due to cell death and endogenous respiration. Instead, the deactivation of bacteria provided by the present invention contributes to reducing bacteria numbers such that the net increase in bacteria within the reaction zone is not in fact exponential. Advantageously, the proportion of bacteria from the reaction zone which are deactivated is sufficient to maintain the concentration of active biomass in the reaction zone substantially constant.

Advantageously, the deactivating step uses non-chemical means. As many chemicals which would be capable of deactivating micro-organisms are toxic to other forms of life, the use of non-chemical means to deactivate the bacteria avoids the need to have a separate zone for the deactivation or to provide means for separating the chemicals before the effluent is discharged to the external environment.

Thus, a second aspect of the invention provides a method of using micro-organisms to treat organic material found in waster water, the method including the steps of:

a) supplying waster water to a reaction zone for aerobic digestion of organic material in the waster water by bacteria; and

b) deactivating a proportion of the bacteria in the reaction zone by non-chemical means to modify the concentration of active bacteria in the reaction zone.

Conveniently, the bacteria are deactivated by breaking up flocs of bacteria to provide loose bacterial cells and small floc particles in the reaction zone to enhance consumption of bacteria by higher organisms. Preferably a mechanical force is used such as a region of high shear stress. The mechanical force may be generated by a jet of fluid. Most advantageously, the bacteria are

deactivated during aeration of the reaction zone. In this way, the two steps of deactivation and aeration may be combined.

A third aspect of the invention provides a method of using micro-organisms to treat organic material found in waste water, the method including the steps of:

a) supplying waste water to a reaction zone for aerobic digestion if organic material in the waste water by bacteria;

b) controlling the rate of supply of the waste water to be sufficient for the bacteria population of the reaction zone to be respiring as in a growth phase; and

c) deactivating a proportion of the bacteria in the reaction zone to maintain constant the concentration of active bacteria in the reaction zone relative to the organic material.

As previously discussed, if the concentration of active bacteria in the reaction zone is maintained constant, the production of sludge is thereby controlled.

Embodiments of the present invention will now be described, by way of example only, and with reference to the accompanying drawings in which:

Figure 1 shows schematically an embodiment of an apparatus provided in accordance with the present invention including an aerator effective to modify micro-organisms;

Figure 2 shows an embodiment of a venturi aerator for use in the apparatus of Figure 1, the aerator including a nozzle for producing the venturi effect; and

Figure 3 shows the nozzle of Figure 2 in greater detail.

Figure 1 shows, schematically, an apparatus for treating raw unsettled sewage and incorporating the apparatus of the present invention. Rags and other gross solids ("screen solids") are removed from the raw sewage as the sewage is passed through screens 1. Large inorganic grit solids are removed via the gritting lanes 2. The remaining sewage liquor flows continuously into a well mixed reaction vessel 3 at a controlled rate of between 1/6th and 1/24th of the volume of the reaction vessel per hour. Treated liquor overflows from the vessel in order to ensure the sewage liquor has a mean residence time in the reaction vessel of between 6 and 24 hours. During this period, the sewage liquor is brought into contact with micro-organisms which feed on the dissolved, colloidal and particulate organic material in the sewage liquor. As the micro-organisms respire, organic material consumed by the micro-organisms are converted into carbon dioxide and water with the generation of energy in a form which may be used by the micro-organisms to grow and reproduce. The rate of growth of a population of micro-organisms is dependent upon a number of environmental factors. In particular, the activity of the population is affected by the concentration of nutrient, the level of dissolved oxygen, the temperature and the pH. The level of dissolved oxygen, temperature and pH can be controlled by correct design and operator input. However, the correct level of nutrient for a process to operate is dependent upon many other factors, not least the history of the micro-organisms and the history of the nutrient supplied. These control the size and the nature of the population of the micro-organisms.

When a population of micro-organisms is fed with a batch of sludge with large organic content, the population of micro-organisms is small relative to the high concentration of nutrients and so the rate of growth of

micro-organisms is large as the micro-organisms reproduce by dividing. This stage is often known as the exponential growth phase of the population.

In the circumstance that no further nutrient is added, the concentration of micro-organisms can greatly exceed the concentration of nutrient. This encourages the growth of protozoa, such as flagellates and ciliates which prey on the simple micro-organisms (bacteria). The overall rate of growth of the micro-organism population thereby decreases as the number of simple micro-organisms consumed begins to approach the number of micro-organisms produced by cell division. This phase is often known as the declining growth phase. In addition, as the concentration of nutrients becomes limiting, the micro-organisms begin to respire using nutrients in their own bodies. This phase is known as the endogenous respiration phase. Finally, large quantities of cells die and cells lysis or decomposition takes place. This process can release nutrient and cause resynthesis of the population. Indeed, cyclic growth and decline of micro-organism population is often observed in the circumstance of batch feeding of sludge (e.g. in prior art extended aeration treatments).

The rate of growth in all of the phases described above can be described by the equation

$$\frac{dX}{dt} = \mu X - k_e X - k_d X$$

where $X$ is the concentration of micro-organisms

$\mu$ is the specific growth rate. This is a measure of the rate of cell division.

$k_e$ is the specific endogenous respiration rate. This is the utilisation of stored cellular materials ending in cell lysis.

$k_d$ is the predatory rate. This is a measure of the feeding of other micro-organisms (protozoa and rotifers) on the bacterial population.

Previously, $k_d$ and $k_e$ have been combined for analysis purposes, because they typically are only of significance compared to the growth term when retention times are high, food to micro-organism ratios are low and the sludge is in the endogenous respiration phase. The effects of death and endogenous respiration are then hard to separate. Values of $(k_d + k_e)$ are typically between 0.02 per day and 0.1 per day in this phase. In the exponential growth phase, when food to micro-organism ratios are high, then the specific growth rate can be as high as 5 per day. In the endogenous phase growth rates are below 0.1 per day.

Conventionally, a negative growth rate has been achieved only by holding the sludge at a low food to micro-organism ratio, either by a slow rate of feed or holding the sludge for tens of days (extended aeration).

Consequently the rate of decrease of sludge is very slow, because it is controlled by the natural endogenous respiration of the population and death of the micro-organisms from "natural" causes.

Oxygen transfer is a critical feature in waste water treatment and is the limiting factor in many processes, and due to the low solubility of oxygen in solution is very energy intensive. The aeration system developed for this treatment process provides the two prime requirements for successful biological oxidation: efficient transfer of oxygen from the air into the waste water being treated, and strong stirring action to keep the waste water and biomass in intimate contact. The enhanced oxygen transfer and fluid motion across the bacterial cell surface means that substrate uptake by

bacteria is also increased and therefore, the substrate in the waste water becomes limiting so that additional energy now required is obtained by the digestion of bacteria by other bacteria, therefore $k_e$ increases. The second effect of the system on the microbial population is the creation of conditions favourable to certain protozoa. The shearing effect of the aeration system sloughs off cells from flocs and breaks some large flocs into smaller ones. The result in shearing a proportion of the flocs is an increased availablility of loose bacterial cells for ingestion by ciliated protozoa and rotifers, resulting in increased population sizes of these organisms, and therefore in $k_d$.

The combined result of floc shearing and the increase in oxygen transfer, and therefore substrate uptake rate, is a constant active sludge concentration in the reactor. Furthermore, this is achieved with high feed rates and low hydraulic residence times, and therefore in conditions typical of exponential growth in population in conventional processes. The rate of change of substrate concentration, or alternatively the rate of feed to the process at constant substrate concentration, is controlled by the rate of feeding of the micro-organisms and the numbers of protozoa.

In the embodiment of Figure 1, the physical stress on the micro-organisms is imposed by an aerator arrangement 4. In the arrangement 4, sludge is removed from the reaction vessel 3 and propelled through a loop 4a, preferentially a closed loop, by a pump 4b. The loop 4a includes a venturi aerator 4c which effects efficient transfer of oxygen from air into the sludge and agitates the treated sludge to keep the sludge and active micro-organisms well mixed. The venturi aerator 4c may be of the self-entraining type, in which the air is introduced purely by pumping sludge through the venturi

aerator, or of the blown type, where the self-entrained air is supplemented by additional air supplied to the venturi unit from a low pressure Roots blower 4d which can supply large volumes of air at relatively low pressure ratios. Hence, sludge, including micro-organisms, is continuously abstracted and circulated through the aeration device. The use of the aerator arrangement enables oxygenation of the sewage liquor and mixing of the sewage liquor/micro-organism mixture to be achieved simply, reliably and with low power consumption.

This very efficient transfer of oxygen into the liquor and accompanying strong stirring action enhances substrate uptake by bacteria to such an extent that the uptake becomes substrate limited so that $k_e$ is increased.

After residing in the reaction vessel 3 for the required mean period, the treated liquor flows into a separation device 5 which is able to separate typically 96% of volatile organic solids and 92% of inorganic solids from the effluent. The separated solids, the solid fraction, is returned to the reaction vessel 3 for further treatment. The remaining effluent, the liquid fraction, may be subjected to further treatment, "polishing", at 6 to reduce the level of fine suspended solids, reduce the concentration of mineralised products or reduce the concentration of toxic compound before discharge of the final effluent, having a composition within the regulation limits, to the water course.

As previously indicated, in addition to effecting aeration and mixing, the aerator arrangement 4 also has the effect of shearing some of the flocs of bacteria in the sludge to provide loose bacterial cells and small floc particles. An embodiment of a venturi aerator adapted for this purpose is shown in Figures 2 and 3. Unless otherwise indicated, all dimensions shown are in millimetres. Dimensions including the reference NB are nominal bore sizes with normal tolerances.

The input to the aerator 4c from the loop 4a comprises a tube 10 through which the sludge flows. The tube ends in a nozzle 12, of stainless steel, shown in greater detail in Figure 3. The nozzle 12 sits within a T joint 14, of carbon steel, one end of which is joined to the tube 10. The second end of the T joint 14 is joined to an inlet 16 through which air may enter the aerator 4c. The third end of the T joint is joined, via a gate valve 18 to a carbon steel pipe 20 which leads to the reaction vessel 3. As sludge flows through the nozzle 12 and into the T joint 14, its pressure energy is converted into kinetic energy by its acceleration through the nozzle. As the speed of the sludge increases, it tends to entrain air supplied via the air inlet 16. As previously discussed, self entrained air may be supplemented by air from a blower.

As the aerated air flows through the pipe 20, it meets with a second constriction provided by a concentric reducer 22. Turbulence created within the concentric reducer by the constriction results in a region of high shear stress. As the aerated and turbulent sludge flows out of the concentric reducer 22, its pressure energy due to the constriction has been converted into kinetic energy by its acceleration through the constriction. The kinetic energy of the sludge is sufficient to shear flocs of bacteria to increase the numbers of loose bacteria and small floc particles in the reaction vessel. These cells and small floc particles can then be consumed by higher organisms such as protozoa and rotifers, thereby increasing the population of these organisms and in effect increasing the rate of predation $k_d$.

The resulting increase in both $k_e$ and $k_d$ enables a steady concentration of biomass to be achieved with higher values of $\mu$, so that overall repiration rates are increased converting organic material into

carbon dioxide and water. Recycling of the sludge through the aerator arrangement means that the sludge can remain in the system until substantially all of the organic material present has been converted into carbon dioxide and water.

For a plant designed to treat, with a mean hydraulic residence time of 6 hours, unsettled sewage with an influent Chemical Oxygen Demand of 500 mg/l, at a volume flow rate of $1400m^3$/day then the aeration vessel is capable of holding a working volume of $400m^3$ at a depth of 6 m.

Mixed liquor in the aeration vessel is pumped through the aeration device at a rate of $100m^3$/h. Air is supplied to the aeration device at a rate of $1000m^3$/h and a pressure of 1.5 bar gauge. On each pass of liquor through the aeration device the fluid motion and greater oxygen transfer across bacterial cell surface is achieved and a proportion of the flocs are sheared.

Modifications to the embodiment described within the scope of the present invention will be apparent to those skilled in the art.

CLAIMS

1. A method of using micro-organisms to treat organic material found in waste water, the method including the steps of:

a) supplying waste water to a reaction zone for aerobic digestion of organic material in the waste water by bacteria;

b) removing a portion of the contents of the reaction zone to produce a liquid fraction and a separated sludge fraction;

c) returning the whole of the separated sludge fraction to the reaction zone; and

d) deactivating a proportion of the bacteria in the reaction zone to modify the concentration of active bacteria in the reaction zone.

2. A method according to Claim 1 wherein the deactivating step uses non-chemical means.

3. A method of using micro-organisms to treat organic material found in waste water, the method including the steps of:

a) supplying waste water to a reaction zone for aerobic digestion of organic material in the waste water by bacteria; and

b) deactivating a proportion of the bacteria in the reaction zone by non-chemical means to modify the concentration of active bacteria in the reaction zone.

4. A method according to Claim 3 including the steps of removing a portion of the contents of the reaction zone to produce a liquid fraction and a separate sludge fraction and returning the whole of the separated sludge fraction to the reaction zone.

5. A method according to any preceding claim wherein the organic material supplied is the waste water to the reaction zone is sufficient for the bacteria population of the reaction zone to be respiring as in a growth phase.

6. A method of using micro-organisms to treat organic material found in waste water, the method including the steps of:

a) supplying waste water to a reaction zone for aerobic digestion of organic material in the waste water by bacteria;

b) controlling the rate of supply of the waste water to be sufficient for the bacteria population of the reaction zone to be respiring as in a growth phase; and

c) deactivating a proportion of the bacteria in the reaction zone to maintain constant the concentration of active bacteria in the reaction zone relative to the organic material.

7. A method according to Claim 6 including the steps of removing a portion of the contents of the reaction zone to produce a liquid fraction and a separated sludge fraction and returning the whole of the separated sludge fraction to the reaction zone.

8. A method according to Claim 6 or Claim 7 wherein the deactivating step uses non-chemical means.

9. A method according to any of Claims 6 to 8 wherein the organic material supplied in the waste water to the reaction zone is sufficient for the bacteria population of the reaction zone to be respiring as in an exponential growth phase.

10. A method according to Claim 5 wherein the organic material supplied in the waste water to the reaction zone is sufficient for the bacteria population of the reaction zone to be respiring as in an exponential growth phase.

11. A method according to Claim 10 wherein the proportion of bacteria in the reaction zone being deactivated is sufficient to maintain the concentration of active bacteria in the reaction zone substantially constant relative to the organic material.

12. A method according to any preceding Claim wherein bacteria are deactivated by breaking up flocs of bacteria to provide loose bacterial cells and small floc particles in the reaction zone to enhance consumption of bacteria by higher organisms.

13. A method according to claim 12 wherein a mechanical force is used to break up said flocs.

14. A method according to claim 13 wherein the mechanical force generates a region of high shear stress.

15. A method according to claims 13 or 14 wherein the mechanical force is generated by a jet of fluid.

16. A method according to any one of claims 12 to 15 wherein the bacteria are deactivated during aeration of the reaction zone.

17. A method according to any preceding claim wherein sufficient oxygen is dissolved in the reaction zone that the aerobic digestion of organic material is limited by the availability of food substrate to the bacteria, so that endogenous respiration is enhanced.

18. An apparatus for treating organic material found in waste water using micro-organisms, the apparatus comprising:

a) a reaction zone arranged for aerobic digestion by bacteria of organic material in waste water supplied thereto;

b) removing apparatus for removing a portion of the contents of the reaction zone to produce a liquid fraction and a separated sludge fraction and for returning the whole of the separated sludge fraction to the reaction zone; and

c) deactivating apparatus for deactivating a proportion of bacteria in the reaction zone to modify the concentration of active bacteria in the reaction zone.

19. An apparatus according to claim 18 wherein the deactivating apparatus is non-chemical in action.

20. An apparatus for treating organic material found in waste water using micro-organisms, the apparatus comprising:

a) a reaction zone arranged for aerobic digestion by bacteria of organic material in waste water supplied thereto;

b) deactivation apparatus which is non-chemical in action for deactivating a proportion of bacteria in the reaction zone to modify the concentration of active bacteria in the reaction zone.

21. An apparatus according to claim 20 comprising removing apparatus for removing a portion of the contents of the reaction zone to produce a liquid fraction and a separated sludge fraction and for returning the whole of the separated sludge fraction to the reaction zone.

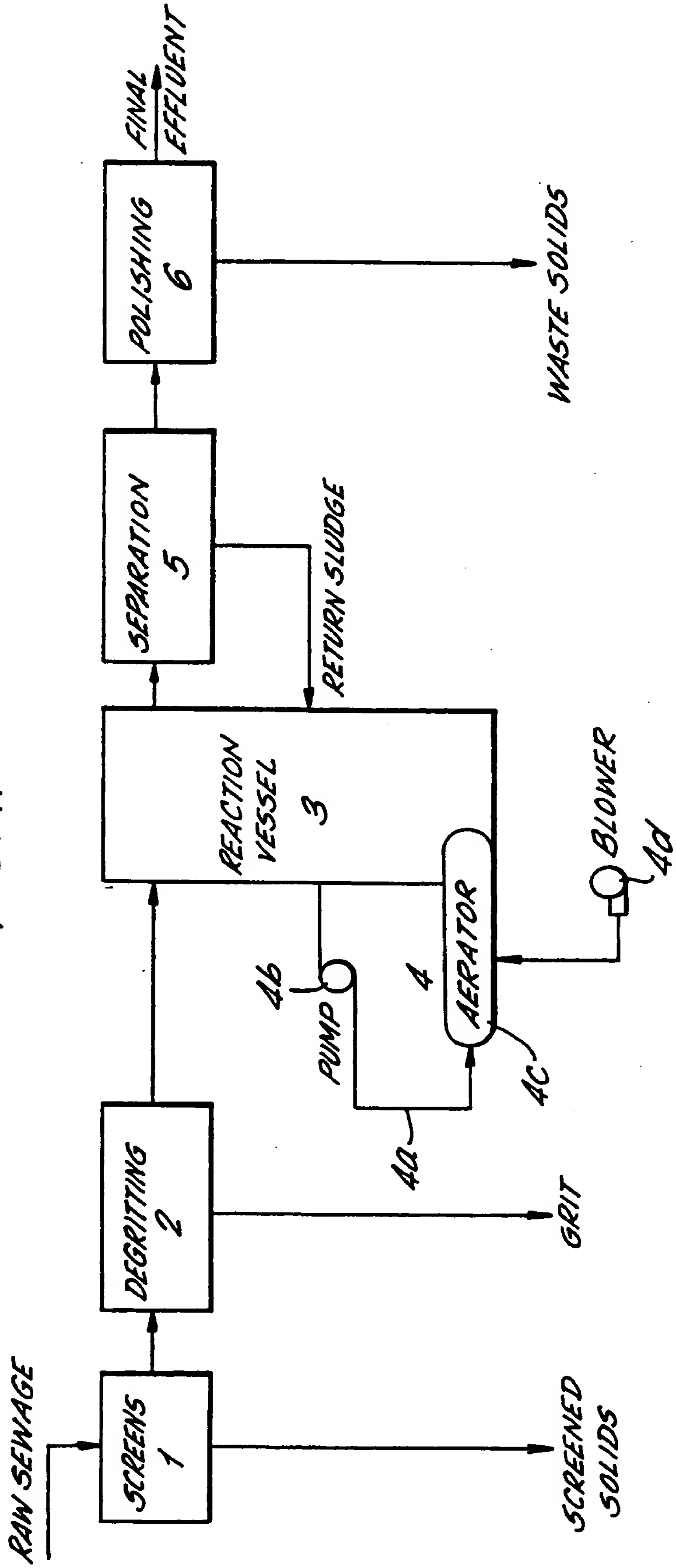
22. An apparatus according to any of claims 18 to 21 wherein the deactivating apparatus is arranged to generate a region of high shear stress in the liquor of the reaction zone to break up flocs of bacteria to provide loose bacteria cells and small floc particles in the reaction zone.

23. An apparatus according to claim 22 wherein the deactivating apparatus generates a jet of fluid.

24. An apparatus according to claim 23 wherein the deactivating apparatus comprises a venturi aerator.

25. An apparatus as claimed in claim 24 wherein the reaction aerator has a jet tube provided with a constriction at the outlet of the jet tube into the reaction zone.

FIG. 1.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PUMP
4b
4a
AERATOR
4
4c
BLOWER
4d
SEPARATION 5
RETURN SLUDGE
POLISHING 6
WASTE SOLIDS
FINAL EFFLUENT

2/2

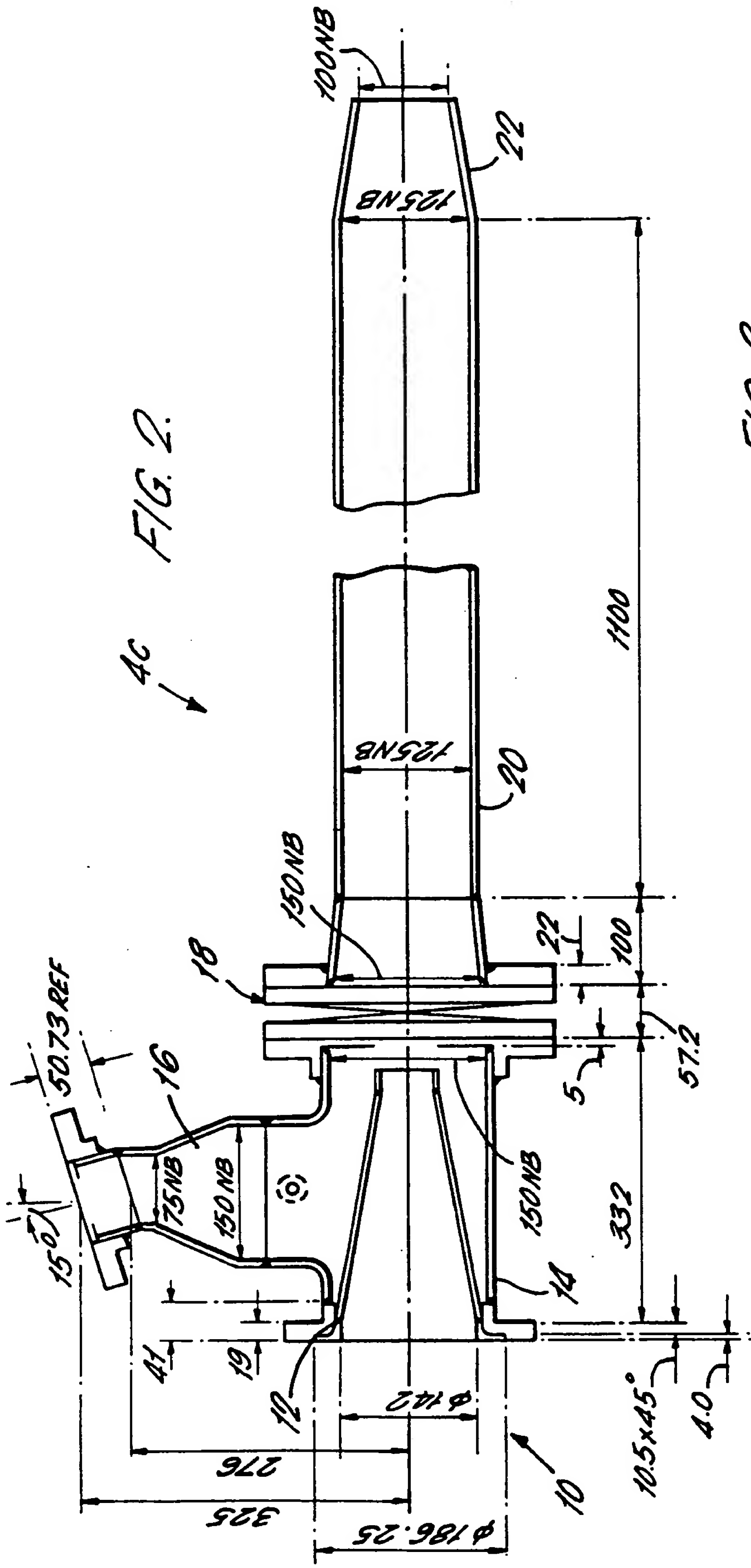
100NB
22
125NB
1100
125NB
20
4C
150NB
18
22
100
57.2
5
50.73 REF
16
75NB
150 NB
150NB
332
14
15°
41
19
12
φ142
10.5x45°
4.0
276
325
φ186.25
10

FIG. 2.

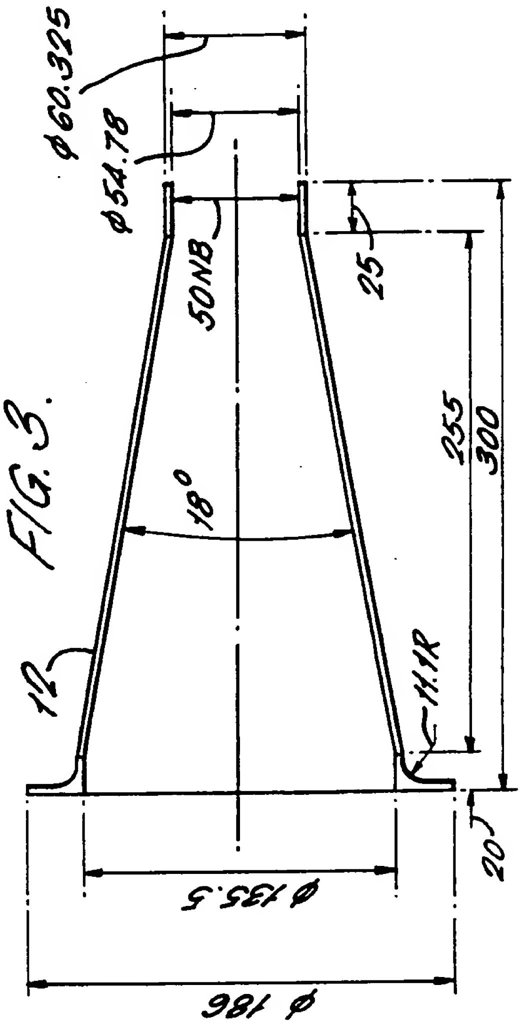
φ60.325
φ54.78
50NB
25
255
300
18°
12
11.1R
20
φ135.5
φ186

FIG. 3.

# INTERNATIONAL SEARCH REPORT

Intern al Application No
PCT/GB 94/02556

**A. CLASSIFICATION OF SUBJECT MATTER**

C 02 F 3/02

According to International Patent Classification (IPC) or to both national classification and IPC 6

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

C 02 F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category * | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | US, A, 4 915 840 (A.F. ROZICH) 10 April 1990 (10.04.90), claims; examples; figs. (cited in the application). -- | 1-25 |
| A | US, A, 4 976 863 (D.M. STEARNS) 11 December 1990 (11.12.90), claims; abstract; figs. ---- | 1 |

☐ Further documents are listed in the continuation of box C.

☐ Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 14 February 1995 | 15. 03. 95 |

| Name and mailing address of the ISA | Authorized officer |
|---|---|
| European Patent Office, P.B. 5818 Patentlaan 2<br>NL - 2280 HV Rijswijk<br>Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,<br>Fax (+31-70) 340-3016 | HOFBAUER e.h. |

# ANHANG

zum internationalen Recherchenbericht über die internationale Patentanmeldung Nr.

# ANNEX

to the International Search Report to the International Patent Application No.

# ANNEXE

au rapport de recherche international relatif à la demande de brevet international n°

PCT/GB 94/02556 SAE 100229

In diesem Anhang sind die Mitglieder der Patentfamilien der im obengenannten internationalen Recherchenbericht angeführten Patentdokumente angegeben. Diese Angaben dienen nur zur Unterrichtung und erfolgen ohne Gewähr.

This Annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The Office is in no way liable for these particulars which are given merely for the purpose of information.

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| Im Recherchenbericht angeführtes Patentdokument<br>Patent document cited in search report<br>Document de brevet cité dans le rapport de recherche | Datum der Veröffentlichung<br>Publication date<br>Date de publication | Mitglied(er) der Patentfamilie<br>Patent family member(s)<br>Membre(s) de la famille de brevets | Datum der Veröffentlichung<br>Publication date<br>Date de publication |
|---|---|---|---|
| US A 4915840 | 10-04-90 | keine - none - rien | |
| US A 4976863 | 11-12-90 | AU A1 51008/90 | 24-08-90 |
| | | AU B2 634690 | 25-02-93 |
| | | DE T 4090163 | 21-02-91 |
| | | JP T2 3505425 | 28-11-91 |
| | | WO A1 9008741 | 09-08-90 |